



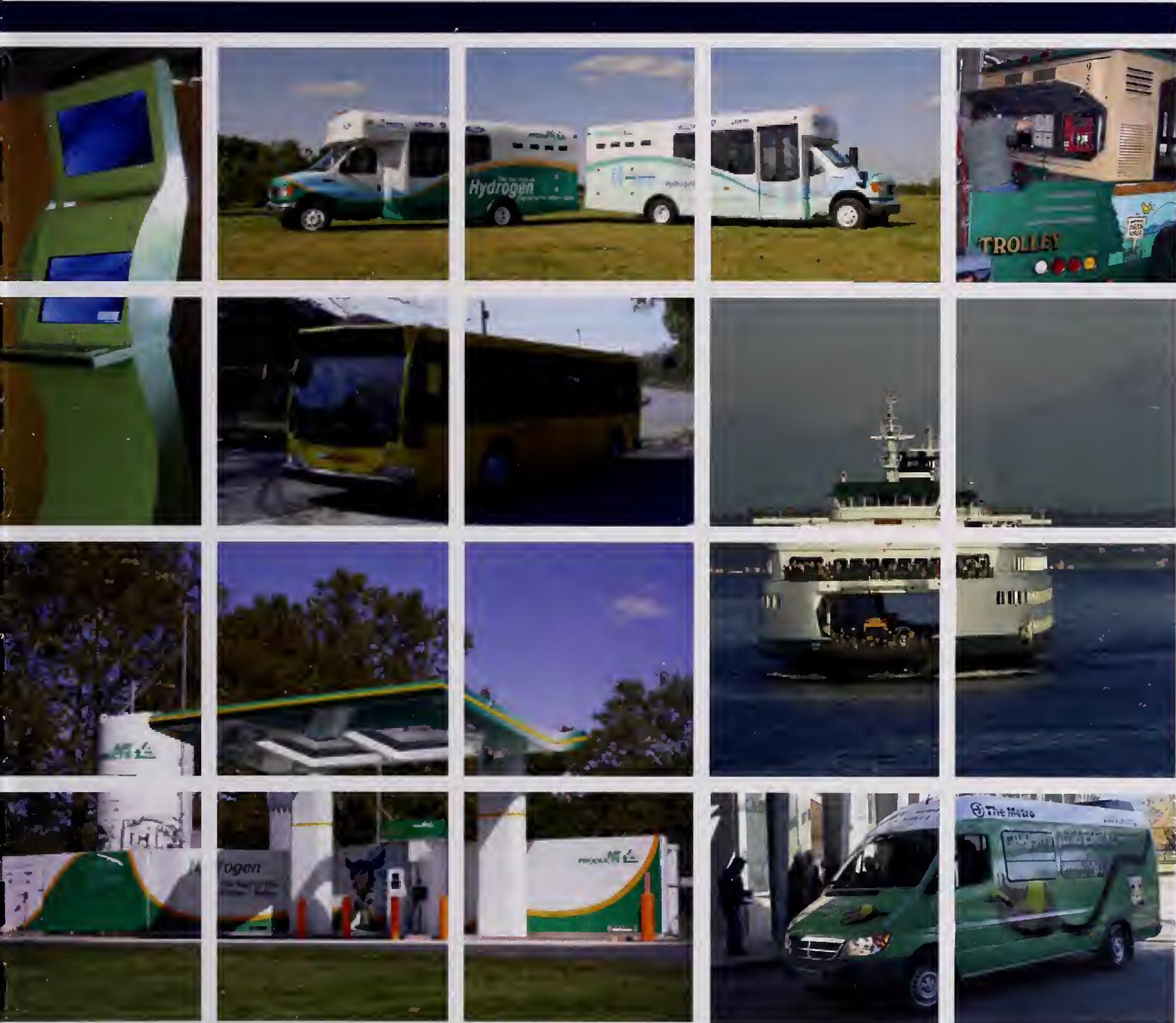
U.S. Department of Transportation
Federal Transit Administration



FTA National Research Programs

Federal Transit Administration

"Delivering Solutions that Improve Public Transportation"



ANNUAL RESEARCH REPORT 2008

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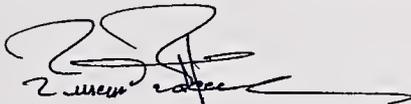
Introduction

I am pleased to present to you FTA's Annual Research Report for FY 2008. Like last year's report, this report highlights many of the achievements FTA has made this past year in support of our strategic research vision to "Deliver Solutions that Improve Public Transportation." In 2008, FTA worked with the Transit Research Analysis Committee to update our strategic research goals and objectives:

- Goal 1. Provide national transit research leadership
- Goal 2. Support increasing transit's market share
- Goal 3. Support improving the performance of transit operations and systems.

The success of FTA's National Research Program in FY 2008 is a testament to the hard work and quality of the researchers and support staff. By working closely with customers and stakeholders, FTA will continue to develop and execute a comprehensive transit research program that delivers results to the American public and provides real solutions to the transit industry.

Given the large number of projects underway at FTA, this report can highlight only some of them. I encourage you to visit the Research, Technical Assistance, and Training section of FTA's website at <http://www.fta.dot.gov/research.html> to learn more about our programs.



Vincent Valdes
Associate Administrator for
Research, Demonstration, and Innovation

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The Strategic Framework

Prepared by the Office of Research, Demonstration, and Innovation (Research Office), the Federal Transit Administration's (FTA) National Research Program Annual Research Report serves as a report card for our strategic research program. This year's report highlights FTA's research accomplishments for fiscal year (FY) 2008, outlines future research needs and plans, and provides realistic expectations for achieving FTA's research goals in the coming years.

Federal Transit Administration Vision, Mission, and Goals

In 2008, with input from the Transit Research Analysis Committee (TRAC), FTA updated its strategic research goals and objectives in response to the changing needs of the U.S. population for safe, efficient, and less costly transportation options. This year's research report links current research programs and projects to the new goals and objectives.

Federal Transit Administration Vision

"Public transportation is the mode of choice in America"

FTA Research Mission

"Deliver Solutions that Improve Public Transportation"

FTA Strategic Research Goals

Provide national
transit
research leadership

Support improving the
performance of transit
operations and systems

Support increasing
transit's market share

FTA’s research program continues to directly support the strategic goals of FTA and the U.S. Department of Transportation (DOT), and helps FTA achieve its mission of delivering solutions that improve public transportation. FTA’s strategic research goals are aligned with DOT’s strategic goals.

| FTA Strategic Research Goals | DOT Strategic Goals |
|---|---|
| Provide National Transit Research Leadership | Organizational Excellence —Advance the Department’s ability to manage for results and innovation. |
| Support Increasing Transit’s Market Share | Reduce Congestion —Advance accessible, efficient, intermodal transportation for the movement of people and goods. |
| Support Improving the Performance of Transit Operations and Systems | Environmental Stewardship —Promote transportation solutions that enhance communities and protect the natural and built environment. |
| | Global Connectivity —Facilitate a more efficient domestic and global transportation system that enables economic growth and development. |
| | Safety —Enhance public health and safety by working toward the elimination of transportation-related deaths and injuries. |
| | Security Preparedness and Response —Balance homeland and national security transportation requirements with the mobility needs of the Nation for personal travel and commerce. |
| | Environmental Stewardship —Promote transportation solutions that enhance communities and protect the natural and built environment. |

Multi-Year Research Program Plan

The *FTA Multi-Year Research Program Plan (FY09 – FY13)* provides descriptive summaries of existing FTA research projects for FY 2009 through FY 2013 and links these projects to the goals and objectives of FTA’s Strategic Research Plan. It further identifies future transit industry research needs aligned with FTA’s research goals, and it describes new research areas that FTA will consider for funding during the next five years.

Highlights and Expectations

This annual report is prepared for transit agencies, congressional committees and staff, transit business leaders, public transportation researchers, DOT modal administrations, and FTA staff. Many of the projects highlighted in FY 2008 will continue in FY 2009.

Highlights from 2008

FTA is on target to deliver, by 2010, 30 major research products, innovations, and techniques that support FTA strategic research goals. In FY 2008, FTA published the following seven major reports:

1. *Electric Drive Strategic Plan*. Draft. September 2008.
2. *2008 Bus Rapid Transit Vehicle Demand & Systems Analysis Update*. FTA-CA-26-7074-2008.1. August 2008. Available at http://www.fta.dot.gov/documents/2008_BRT_VDSA_Final.pdf.
3. *An Evaluation of the Market for Small-to-Medium-Sized Cutaway Buses*. Final Report. MI-26-7280.07.1. December 2007. Available at <http://www.fta.dot.gov/documents/AnEvaluationofMarketforSmalltoMediumSizedCutawayBuses.pdf>.
4. *Biodiesel Fuel Management Best Practices for Transit*. FTA-MO-26-7009.2007.1. November 2007. Available at http://www.fta.dot.gov/documents/Biodiesel_Fuel_Management_Best_Practices_Report.pdf.
5. *Advanced Network Planning for Bus Rapid Transit: The "Quickway" Model as a Modal Alternative to "Light Rail Lite."* FL-26-7104-4. February 2008. Available at http://www.fta.dot.gov/documents/BRT_Network_Planning_Study_-_Final_Report.pdf.
6. *Evaluation of Transit Applications of Advanced Parking Management Systems*. Final Evaluation Report. FTA-TRI-11-2008.1. May 2008. Available at <http://www.fta.dot.gov/documents/ParkingManagementEvaluationReport.pdf>.
7. *Hydrogen Fuel Cell Transit Bus Evaluations: Joint Evaluation Plan for the U.S. Department of Energy and the Federal Transit Administration*. NREL/TP-560-42781-1. May 2008. Available at <http://www.fta.dot.gov/documents/HydrogenandFuelCellTransitBusEvaluations42781-1.pdf>.

Expectations for 2009

FTA will continue to examine how it can better provide national transit research leadership for the transit research community. As part of this effort, FTA will produce the “FTA Multi-Year Research Program Plan (FY10 – FY14).” FTA will also review its current *Strategic Research Plan*¹ to assure that it continues to support FTA and DOT strategic goals and objectives.

In 2009, FTA will organize its planning and research around nine strategic research areas:

- Electric drive (bus and rail)
- Bus
- Rail
- Intelligent transportation systems (ITS)
- Safety, security, and emergency preparedness
- Policy, economics, law, and finance
- Management and maintenance operations
- Infrastructure and construction technology
- Sustainable transport.

FTA will collect and analyze existing research information in these areas, will develop limited-scope strategic research plans, will begin syntheses of practical bodies of knowledge that transit agencies and the transit community in general can use in decision making, and will identify needed research projects.

Further, FTA will continue to encourage its offices to adopt more robust methods for developing research project ideas and plans that support DOT and FTA goals. Within the Transportation Cooperative Research Program (TCRP), the National Transit Institute (NTI), and the University Transportation Centers Program (UTCP), FTA will actively support and encourage the development of new research projects aligned with its strategic research goals.

In addition, in 2009, FTA will:

- Identify targets for its strategic research objectives
- Complete a strategic plan for its ITS research
- Complete a strategic plan for its International Public Transportation Program
- Complete a strategic plan for dissemination of research information
- Deliver a report to Congress on rail modernization needs
- Deliver a report to Congress on the results of the Cooperative Procurement Pilot Program.

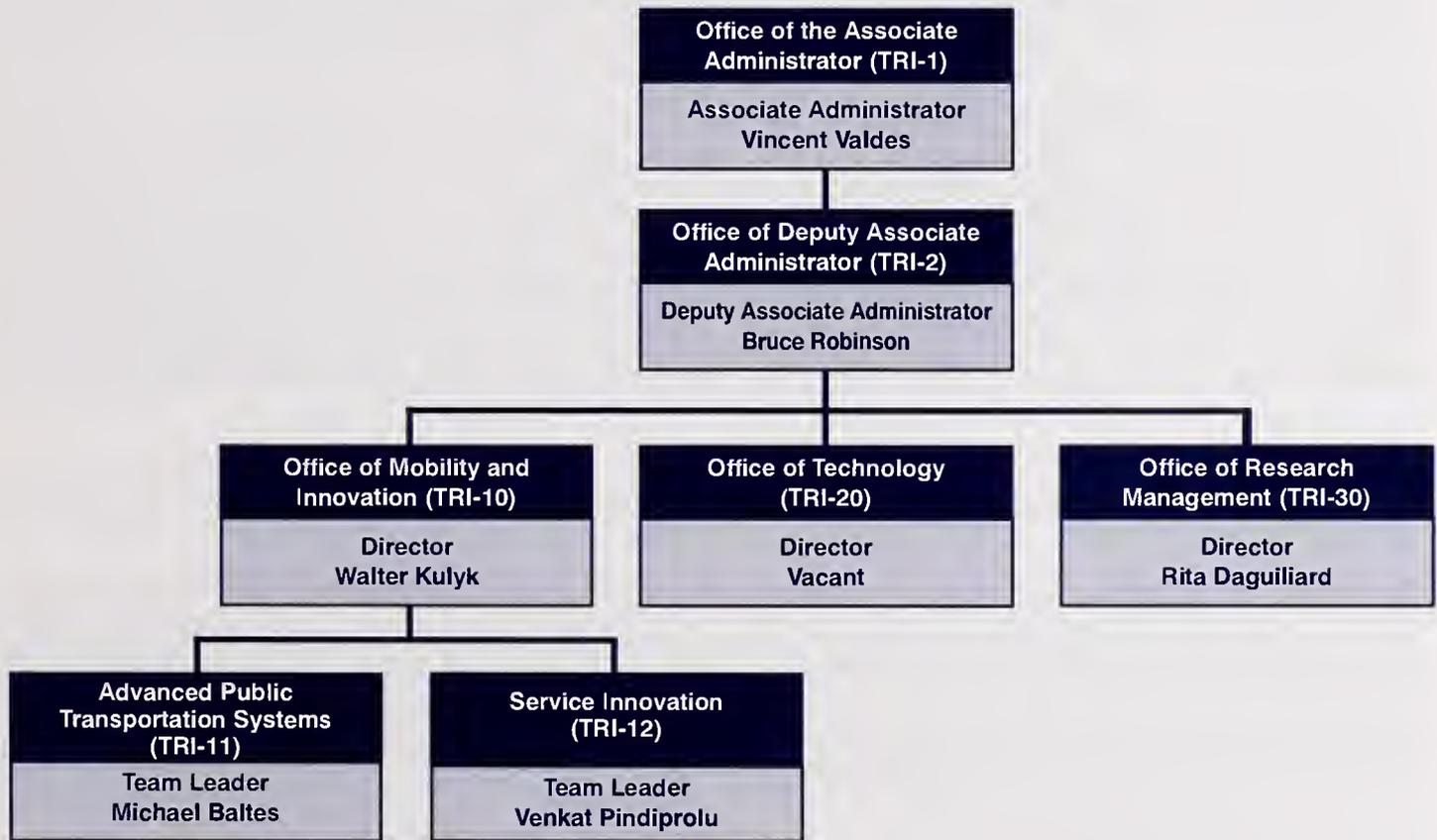
¹ Available at www.fta.dot.gov/documents/Strategic_Plan_9-30-05.doc.

The Office of Research, Demonstration, and Innovation

Responsible for maintaining the national perspective for transit research, the Office of Research Demonstration and Innovation (Research Office) manages and oversees FTA’s transit research program and provides industry and policy makers with the information and skills to make good business decisions about transit technology, operational, and capital investments.

The Research Office has seven divisions to administer and oversee FTA’s research agenda and to disseminate results and information.

FTA Office of Research, Demonstration, and Innovation



Progress Toward Strategic Research Goals

The FTA Research Office has three specific goals and 12 objectives for a comprehensive national transit research program aligned with industry and public needs and DOT's strategic goals. In 2008, FTA successfully completed projects under all of these goals. More than 90 percent of these projects were completed on time and within budget. Descriptions of selected projects in progress and completed in 2008 are provided below, indexed by FTA strategic research goal and objective.

Goal 1: Provide National Transit Research Leadership

Goal 1 Objectives

- 1.1 Provide vision and prepare the nation for transit advancements
- 1.2 Explore strategic partnerships to achieve transit research goals
- 1.3 Synthesize research results to provide useful bodies of knowledge for transit industry decision makers and to shape the national transit research agenda

As the only federal agency with responsibility for assuring the growth and vigor of the nation's transit systems, FTA is responsible for addressing transit research from a national perspective. FTA research programs support national goals by coordinating FTA research with other DOT operating administrations. In addition, because FTA's research funds are limited, FTA contributes to, leverages, and builds on the research of others. Besides leading and supporting domestic research, FTA also shares international best practices with the U.S. transit industry and provides decision makers with the tools and information they need to make informed decisions.

FTA is also initiating better organization of its research projects by developing strategic plans for the nine research areas listed in "Expectations for 2009" on page 4. In FY 2008, FTA worked with the transit industry to complete the first strategic plan, the draft *Electric Drive Strategic Plan* (EDSP). The EDSP is the initial step in developing bodies of knowledge for bus and rail electric drive transportation for the transit industry. FTA will synthesize and incorporate the results of the research outlined in the EDSP into these bodies of knowledge, and will use them to guide future research and research planning.

In 2009, FTA will complete strategic plans for its ITS research, for its international program, and for disseminating its research results. FTA will use strategic planning over time to support the development of the bodies of knowledge for all of its transit research.

Highlights of FY 2008 Accomplishments

Laying out the Transit Research Agenda. FTA's *Multi-Year Research Program Plan (FY09 – FY13)* provides descriptive summaries of FTA's existing and proposed research products and links them to the goal and objectives of FTA's Strategic Research Plan.

Transit Research Analysis Committee. Funded through the Transportation Research Board (TRB), TRAC provides independent review and assessment of FTA's research agenda and works with FTA to recognize and respond to changing research needs affected by changing social, economic, and environmental conditions. In 2008, FTA met twice with TRAC to discuss new directions and the redesign of FTA's research goals and objectives.

Electric Drive Strategic Plan

The *Electric Drive Strategic Plan (EDSP)* was developed to establish long-term electric drive research goals through 2030. It defines the vision and research needs to advance bus and rail transit vehicle design, traction power, propulsion, and performance, and outlines six program areas composed of projects to be carried out between 2010 and 2014.

The transit electric drive research vision is, by 2030, to make zero- and near-zero-emission, high-efficiency, affordable transit vehicles available from domestic suppliers to transit agencies across the country. The electric drive research goals are to increase efficiency, lower emissions, and achieve superior performance. Initial project ideas were developed in the following program areas: program implementation, vehicle energy management, electrification of accessories, bus design, rail energy management, and locomotive design.

Goal 2: Support Increasing Transit's Market Share

Goal 2 Objectives

- 2.1 Identify methods to increase transit system capacity
- 2.2 Investigate methods to reduce the time needed to plan and build infrastructure
- 2.3 Perform research to improve rider experience

Goal 2 recognizes and draws attention to a growth area for transit. Increasing transit's market share is important because transit ridership facilitates a range of societal benefits. These benefits include increasing mobility, improving safety, reducing air pollution, and improving energy efficiency. Increasing ridership also supports the DOT's national initiative to address congestion.²

² *National Strategy to Reduce Congestion on America's Transportation Network*. DOT. May 2006.

Highlights of FY 2008 Accomplishments

Objective 2.1 Identify Methods to Increase Transit System Capacity

Multi-Modal Trip Planner System. The Chicago Regional Transit Authority (RTA) is developing a web-based trip planning system that provides users with door-to-door travel options regardless of travel mode or how many separate transit agencies would actually provide service for a given trip. The trip planning system currently considers transit (bus and rail); driving by automobile; walking, including walking to transit; and multi-modal (for example, driving by automobile to bus or rail transit) options. Future options may include bicycling, carpooling, and intercity bus and rail. This year, RTA conducted a beta release of the website for local and national stakeholders.

Regional Rail On-Board Payment. Using radio-frequency-identification (RFID) technology and commercial off-the-shelf hardware, the Southeastern Pennsylvania Transit Authority (SEPTA) successfully developed and tested a prototype on-board electronic fare payment system for commuter rail service. The system uses a personal digital assistant (PDA) computer and a smart phone to validate contactless smart cards that contain stored value, time periods, or stored rides. The hand-held PDA also records cash transaction information, issues receipts, and downloads data wirelessly to a database.

2008 Bus Rapid Transit Vehicle Demand and Systems Analysis Update

2008 Bus Rapid Transit Vehicle Demand and Systems Analysis Update is a revision of the analysis of vehicle and system preferences for bus rapid transit (BRT) communities published in 2002³ and 2004⁴. This update includes a compilation of data collected through reviews of reports and interviews with 63 BRT communities. It documents the current market demand preferences for BRT vehicle characteristics and systems and uses current data on ongoing and planned BRT activities to predict the future potential and direction of BRT in the United States.

Data collected for this update were sorted into four categories: infrastructure, intelligent transportation systems (ITS), transit-oriented development (TOD)/land use, and vehicles. Major findings included:

- BRT is experiencing significant growth in the United States, with an estimated expansion to at least 60 communities by 2017. The number of communities with dedicated right-of-ways is expected to more than double in the next ten years.
- Modern U.S. BRT vehicle design has improved significantly but still lacks the aesthetics of the European model designs. Interest in stylized vehicles over conventional vehicles is increasing, and a significant but unfilled interest exists in specialized vehicles. Significant demands for tail design exist but are not being met.
- Biodiesel fuels are becoming more popular, and hybrids are surpassing internal combustion engines for BRT systems.

³ *Bus Rapid Transit Vehicle Demand and Supply Analysis*. CALSTART. September 2002.

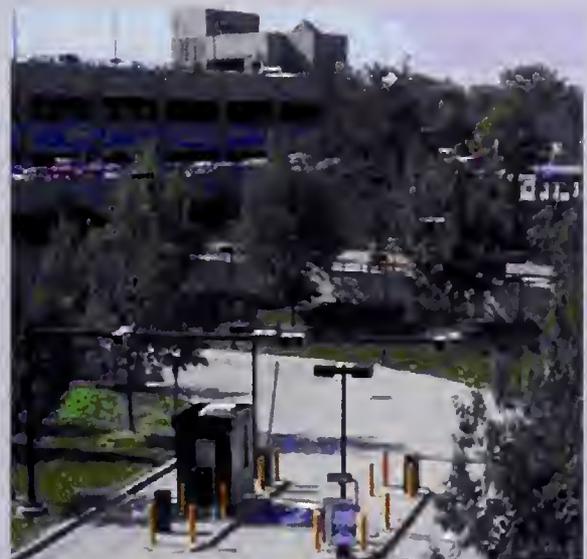
⁴ *Bus Rapid Transit Vehicle Demand and Supply Analysis Update*. CALSTART. June 2004.

Uses of Higher-Capacity Buses in Transit Service. TCRP Synthesis 75, *Uses of Higher Capacity Buses in Transit Service – A Synthesis of Transit Practice*, explores where and how high-capacity buses are being deployed in North America in regular and flexible public transit services, including in trunk, express, long-distance commuter, BRT, and special (e.g., sports and holiday events) services. It also compares high-capacity buses with conventional buses on a wide range of planning, operational, and maintenance factors. High-capacity buses in this study included articulated, double-deck, 45-foot, and other buses that had increased passenger capacity compared with conventional 40-foot buses.

Objective 2.3 Perform Research to Improve Rider Experience

Evaluation of Transit Applications of Advanced Parking Management Systems

Throughout the United States, transit agencies have begun implementing advanced parking information systems to increase customer satisfaction and improve traffic operations. Through the use of variable message signs, these systems provide motorists with real-time information about parking availability at appropriate decision points on their routes so that they can make informed decisions about where to park. Currently, these systems are operational in a variety of environments, including central business districts, airports, and transit park-and-ride lots. Until now, it was generally assumed that, when deployed in a transit environment, advanced parking management systems usually increase parking at a parking lot that is currently under-used, increase transit ridership, and improve customer satisfaction.

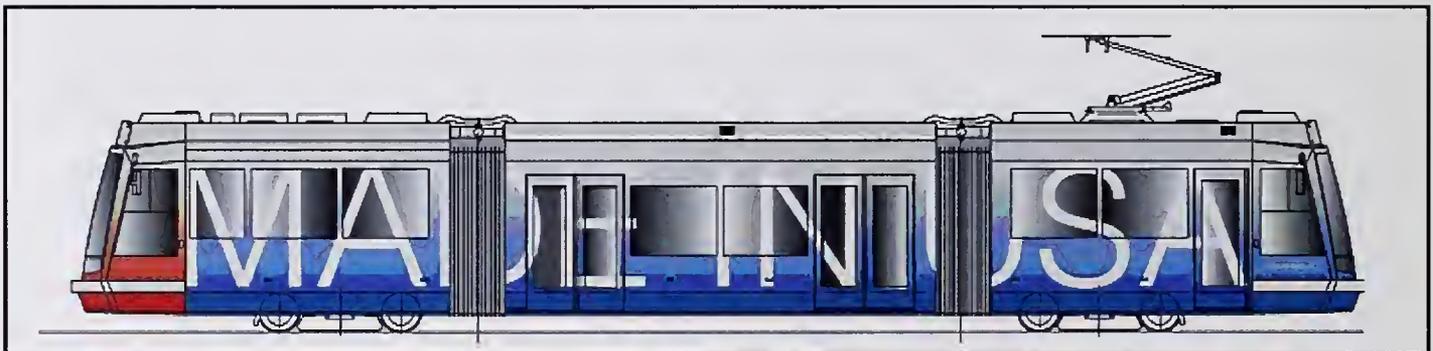


A parking management system at a commuter “park and ride” in Montgomery County, MD, has increased customer satisfaction.

Evaluation of Transit Applications of Advanced Parking Management Systems – Final Evaluation Report documents the impacts of two parking management systems deployed in transit applications in Chicago, IL, and Montgomery County, MD, in terms of parking alternatives awareness and utilization, traffic circulation, transit ridership, and customer satisfaction. A variety of methods were used to obtain and analyze data. The results showed that, in general, advanced parking management systems increased customer satisfaction. Previous assumptions of increases in parking lot utilization and transit ridership were not substantiated.

United We Ride/Mobility Services for All Americans. Funded jointly by FTA and the DOT's ITS Joint Program Office (JPO), the United We Ride (UWR)/Mobility Services for All Americans (MSAA) program creates flexible and accessible transportation services, especially for targeted populations. Begun in 2004, the program first identified technologies that could enhance transportation coordination. In 2006, the ITS JPO provided funding to eight demonstration sites to develop system designs for travel management coordination centers (TMCCs) that could deliver enhanced human service transportation across a variety of operational environments and scenarios. In 2008, the eight sites completed their TMCC designs. Beginning in 2009, three sites (Camden County [NJ] Workforce Investment Board, Paducah Area [KY] Transit System, and Lower Savannah Council of Governments [Aiken, SC]) will implement their designs, demonstrating multiple TMCCs of various sizes and functionalities, including urban, small urban, and rural, and use various partnership types to fulfill local human service transportation needs.

Streetcar Prototype. In FY 2008, TriMet and the City of Portland Office of Transportation, OR, completed the design and started assembly of a new streetcar, the Astra design from Skoda Manufacturing in the Czech Republic. The streetcar, which is being manufactured in the United States, is projected to be completed and deployed on the Portland Streetcar system for testing and reliability evaluation in FY 2009.



The new TriMet, City of Portland streetcar is the Astra design from Skoda Manufacturing in the Czech Republic.



The mid-body section shell and frame of the new TriMet/City of Portland streetcar awaits installation of rooftop components and interior appurtenances.

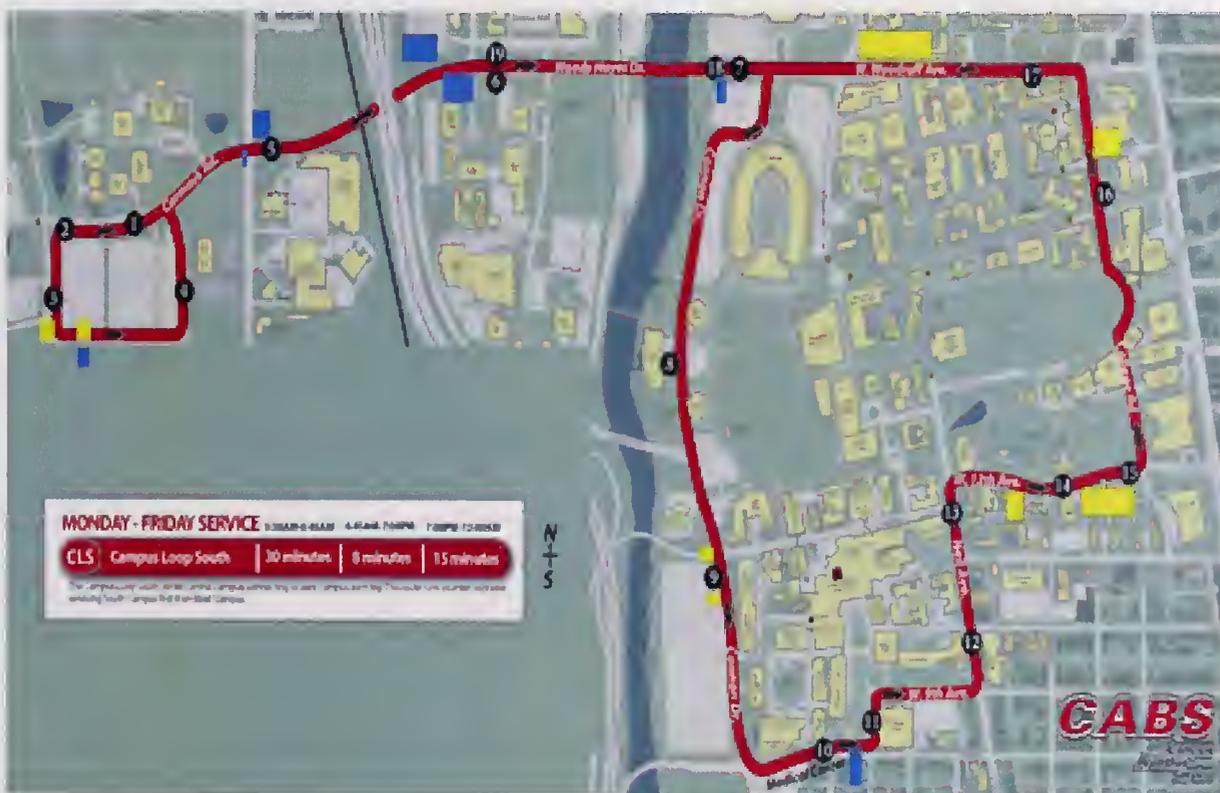
Locating Congestion by Automatic Passenger Count Data—An ITS Pilot.

The Ohio State University (OSU) is conducting a pilot study of Central Ohio Transit Authority (COTA) bus routes on the OSU campus to explore the use of automation for traffic and passenger data collection. OSU is using automated passenger count (APC) data to estimate passenger origin-destination flows and automatic vehicle location (AVL) data to determine recurring traffic congestion.



Boarding and alighting passengers are sensed by the OSU APC system.

- Congestion after 3:00pm
- Congestion before 3:00pm



AVL data show locations of congestion on an OSU campus bus route.

Motivating Communities to Ride Public Transit. TCRP Report 122, *Understanding How to Motivate Communities to Support and Ride Public Transportation*, explores the methods and strategies that public transit agencies in the United States and Canada use to enhance their public images and motivate the support and use of public transportation. The report identifies and describes methods and strategies used by other industries (comparable to public transportation) to enhance their public image and to motivate the use of their products and services. It also examines the perceptions and misperceptions of public transit, and the extent to which such perceptions affect support. The report also identifies effective communication strategies, campaigns, and platforms for motivating individuals to support public transit, as well as ways to execute those strategies, campaigns, and platforms.

Community Planning to Increase Ridership. Transit-oriented development (TOD) is an approach to community planning that encourages compact, mixed-use development while increasing transit ridership and yielding more livable communities. Transit agencies are at the forefront in implementing TOD and stand to gain the most from ridership increases. TCRP Report 128, *Effects of TOD on Housing, Parking, and Travel*, explores the demographics of TOD residents and employers and their motives for locating in TODs, examines the travel characteristics of residents both before and after moving to a TOD, and reviews the potential effect of land-use and design features on travel patterns, transit ridership, and the decision to locate in a TOD.

Goal 3: Support Improving the Performance of Transit Operations and Systems

Goal 3 Objectives

- 3.1 Perform research to improve capital and operating efficiencies
- 3.2 Perform research to improve transit planning and forecasting
- 3.3 Perform research to improve mobility, rural services, and services for targeted populations
- 3.4 Investigate the use of high-efficiency technologies and alternative energy sources
- 3.5 Perform research to reduce transit environmental impacts
- 3.6 Perform research to improve safety, security, and emergency preparedness

The federal government has invested billions of dollars in U.S. transit systems. These assets must be maintained and strengthened to accommodate growing demand for safe, reliable, and affordable public transit, as well as a cleaner environment.

Over the past 15 years, transit construction costs have escalated rapidly. The American Association of State Highway and Transportation Officials (AASHTO) estimates that construction costs increased nearly 30 percent between 1993 and 2006 and projects that they will rise to nearly 50 percent by 2010. Transit operations also face considerable challenges to controlling costs. Primarily due to the addition of new systems and the expansion of existing ones from 1997 to 2006, operating expenses increased nearly 38 percent, to a total of \$24.6 billion.⁵

⁵ 2006 *National Transit Summaries and Trends*. http://www.ntdprogram.gov/ntdprogram/pubs/NTST/2004/HTML%20files/2004_NTST.htm.

The transit industry needs information to make appropriate decisions on service operations. Transit agencies have increasingly focused on incorporating new fuels and propulsion technologies to make their systems cleaner and more efficient and to reduce fuel consumption. Sometimes clean and efficient technologies are required to address emissions standards set by the U.S. Environmental Protection Agency (EPA) and state agencies such as the California Air Resources Board.⁶ They can also significantly improve operational efficiency.

Public transit is important for rural America's 30 million transit-dependent persons—not only older Americans, but also low-income families and people with disabilities. However, 40 percent of America's rural populations currently have no access to public transit, and another 24 percent have very little access.⁷ The transit industry needs information to address cost-effective transit service in rural areas as well as services for targeted populations.

Public transit continues to be one of the safest modes of travel in the United States. According to the National Safety Council's 2007 "Injury Facts," riding a transit bus or commuter rail is 25 times safer than traveling by car.⁵ However, in 2005, transit agencies reported 236 fatalities. In addition, fatalities associated with commuter rail rose to 105, the second highest number in the past ten years.⁸ Thus, safety remains a priority for FTA and transit operators.

Security involves protection against an intentional act of violence or personal harm from a criminal or terrorist act. By statute, lead responsibility for public transportation security against terrorism threats rests with the Department of Homeland Security (DHS). FTA works closely with DHS to address protection and preparedness related to terrorism threats. Criminal acts against transit passengers, employees, or property are addressed directly by FTA. In recent years, emergency preparedness for natural disasters has also become a high priority.

Highlights of FY 2008 Accomplishments

Objective 3.1 Perform Research to Improve Capital and Operating Efficiencies

Standards Development. The American Public Transportation Association (APTA) is the designated standards development organization for transportation. APTA currently has 12 different working groups developing all types of standards and recommended practices for bus and rail transportation. In FY 2008, FTA increased their funding of APTA by \$0.9 million, resulting in a total investment of \$1.9 million for the continued development of industry standards and recommended practices for safe, efficient, and secure transit operations.

In FY 2008, APTA published five security-related recommended practices (RPs) in security emergency management (SEM) and security infrastructure (SIS):

- Recommended Practice for Continuity of Operations, APTA SS-SEM-RP-001-08
- Recommended Practice for First Responder Familiarization of Transit Systems, APTA

⁶ *Analysis Of Electric Drive Technologies For Transit Applications: Battery-Electric, Hybrid-Electric, and Fuel Cells*. FTA-MA-26-7100-05.1. Final Report. August 2005. Available at http://www.fta.dot.gov/documents/Electric_Drive_Bus_Analysis.pdf.

⁷ American Public Transportation Association. 2008. *2008 Public Transportation Fact Book*. June.

⁸ *Transit Safety and Security Statistics and Analysis Annual Report, Fatalities by Mode and Year*. Available at <http://transit-safety.volpe.dot.gov/Data/samis/default.asp?ReportID=2>.

SS-SEM-PR-002-08

- Recommended Practice for Security and Emergency Management Aspects of Special Event Service, APTA SS-SEM-RP-004-08
- Recommended Practice for Trash/Recycling Container Placement to Mitigate the Effects of an Explosive Event, APTA SS-SIS-RP-001-08
- Recommended Practice for CCTV Camera Coverage and Field of View Criteria for Passenger Facilities, APTA SS-SIS-RP-002-08.

These recommended practices are available at <http://www.aptastandards.com/PublishedDocuments/PublishedStandards/Security/tabid/271/Default.aspx>.

An Evaluation of the Market for Small-to-Medium-Sized Cutaway Buses

As a follow-on to the *Non-Rail Vehicle Market Viability Study* completed by FTA in 2005, *An Evaluation of the Market for Small-to-Medium-Sized Cutaway Buses* assesses the viability of small and medium cutaway buses in the U.S. transit bus market. This study includes interviews with manufacturers and transit agencies using these types of buses, and then provides an overview of the existing market, including an analysis, observations, and recommendations.

BUSolutions. BUSolutions is researching an easily maintainable, next-generation bus designed with state-of-the-art engineering to achieve a significantly lower cost of ownership. The Automation Alley Technology Center is currently developing the prototype. Although the prototype uses conventional components, materials, and construction methods, it will meet U.S. EPA emissions standards for 2010 and will represent world-class fuel economy for a diesel engine. The bus will operate with no changes to infrastructure or personnel skill set require-



The computer-aided design (CAD) image of BUSolutions, with side panels removed for clarity, shows an elegant design that incorporates long-life, power-efficient components.

ments.

Performance Measure Forums. In FY 2008, FTA held three performance measure forums for stakeholders and other interested parties to discuss the development of performance metrics. The topics of the three forums were FTA's large externally-visible programs, FTA's internal processes, and leading indicators.

Signal Priority Control Strategies and Modeling Tools. This year, the California Department of Transportation addressed transit signal priority deployment issues, including the application of ITS Protocol National Transportation Communications for ITS Protocol (NTCIP) 1211 signal control and prioritization standards and the implementation of transit signal priority systems and infrastructure. They also evaluated transit signal priority models and guidance on transit signal priority planning and analysis methods, including simulation and regional modeling tools.

Transit Intelligent Transportation Systems in Washoe County. In 2008, the Regional Transportation Commission of Washoe County completed the *Regional Transportation Commission of Washoe County Transit Intelligent Transportation System Implementation Evaluation Study* and the *Intelligent Transportation Systems Implementation Evaluation Study, Technical Memorandum, Data Analysis*. These reports evaluate the procurement, implementation, and operation of transit ITS in Washoe County, NV, from the perspective of the deploying agency. They provide insight and lessons learned considering the deployment of transit ITS to improve system efficiency, customer service, and safety.



The Regional Transportation Commission of Washoe County evaluated the procurement, implementation, and operation of transit ITS from the perspective of the deploying agency.

Promising Emerging Technologies for Transit. The declining costs of communications, data storage, and data retrieval are accelerating the opportunities spawned by the Internet and other information and communications technologies. Selecting investments in technologies, processes, and people to reduce costs and increase productivity presents challenges to transit managers, who must weigh the costs, benefits, and risks of changing the ways services are delivered. TCRP Report 84, *e-Transit: Electronic Business Strategies for Public Transportation, Volume 8, Improving Public Transportation Technology Implementations and Anticipating Emerging Technologies*, explores the value of current technologies used in public transportation, examines methods for improving the success of technology implementation, and reviews five promising emerging technologies with application for transit agencies.

Making Decisions About Local Travel. A variety of complex, interacting factors influence how, where, and when people travel in the United States. Household and personal travel is affected primarily by where individuals live and work which, in turn, is influenced by community characteristics such as population density, geography, available infrastructure, employment locations, institutional arrangements, and economic conditions. Transportation planners have long sought to analyze travel in terms of standard factors such as age, income, sex, car ownership, service availability, and price elasticity. TCRP Report 123, *Understanding How Individuals Make Travel and Location Decisions: Implications for Public Transportation*, explores a broader social context for individual decision making related to residential location and travel behavior. It will help public transportation planners and marketers, modelers, and policy makers understand how travelers' choices are influenced by their larger social contexts.

Update of AVL Systems for Bus Transit: Update. TCRP Synthesis 73, *AVL Systems for Bus Transit: Update*, explores the uses of computer-aided dispatch/automatic vehicle location (CAD/AVL) systems in fixed-route and demand-responsive services (bus AVL), as well as changes in agency practices related to the use of AVL systems. It presents information on the characteristics of bus AVL systems; on transit agencies' experiences with designing, procuring, integrating, and using these systems; and on benefits and costs. This synthesis updates TCRP Synthesis 24, published in 1997.

Objective 3.2 Perform Research to Improve Transit Planning and Forecasting

Advanced Network Planning for Bus Rapid Transit

Within the past decade, Bus Rapid Transit (BRT) has become a fixed and growing part of the U.S. transit landscape, with numerous projects being planned, built, and operated. However, considerable confusion remains about what exactly constitutes a BRT system. Transit stakeholders in the United States correlate BRT with light rail transit and refer to this type of system as “Light Rail Lite.” A Light Rail Lite BRT system typically has a single BRT route that serves a corridor and has some measure of transit priority. Unlike U.S. systems, international BRT systems are often planned and constructed with grade-separated bus infrastructures that support a range of express and branching services.

Advanced Network Planning for Bus Rapid Transit: The “Quickway” Model as a Modal Alternative to “Light Rail Lite” introduces the new terms Quickway and T-way into the discussion of BRT systems and compares Quickway BRT systems to T-Ways. A Quickway, as defined in the report, is a primarily grade-separated busway that can support express and all-stops operations. Functionally, a busway is a Quickway if a bus can traverse its length without being stopped or slowed by automobile traffic, pedestrians, or buses that are loading or discharging passengers. T-Ways are busways that have grade crossings.

New BRT systems can be designed and constructed either as T-Way systems or as Quickways. Quickway systems offer faster travel times, generally higher capacity, and fewer traffic impacts, and produce noticeably greater operating cost benefits than T-Ways. However, Quickway systems require their own planning, cost, and operating logic. The report identifies a number of factors that transit agencies and regional planners should consider when evaluating these systems for specific applications.

Objective 3.3 Perform Research to Improve Mobility, Rural Services, and Services for Targeted Populations

Rural Intelligent Transportation Systems. In 2006, the Central Florida Regional Transportation Authority (LYNX) and the Polk County Transit System (PCTS) agreed to coordinate paratransit services in Osceola and Polk Counties, FL, under a rural intelligent transportation system (RITS) project. In 2008, as a six-month interagency demonstration, LYNX and PCTS completed their first coordinated paratransit trips where PCTS and LYNX, using a central connection, scheduled trips on each other’s manifests and coordinated electronic billing. This demonstration showed that interagency cooperation can increase efficiency of paratransit operations, and reduce overall costs while increasing transit opportunities.

Enhanced Human Service Transportation Models. Through Model Orlando Regionally Efficient TMCC system development and design, LYNX is using advanced technologies to help public and private transportation providers from Orange, Osceola, Seminole, and Polk Counties to share resources.

PickUpLine Flexible Route for Paratransit. In 2008, LYNX and PCTS established an ADA-accessible hybrid service that allows customers who would typically require paratransit services to transfer from a demand response “PickUpLine” vehicle to a traditional fixed route vehicle. Customers are returned to the drop-off location for the reverse trip. The new “flexible route” system allows paratransit customers more independence and mobility. The service itself is a hybrid between regular demand response paratransit and traditional fixed route service.



Small demand-response vehicles link paratransit customers to fixed-route-services, increasing customers' independence and mobility.

Improving Demand Estimations for ADA Complementary Paratransit. The Americans with Disabilities Act of 1990 (ADA) created a requirement for complementary paratransit services for all public transit agencies that provide fixed-route service. Complementary paratransit service is intended to complement the fixed-route service and serve individuals who, because of their disabilities, are unable to use the fixed-route system. TCRP Report 119, *Improving ADA Complementary Paratransit Demand Estimation*, examines tools and methods designed to predict demand for complementary paratransit service by public transit agencies that comply with legal requirements for level of service as specified by the ADA and implementing regulations.

Integrating Non-Dedicated Vehicles into Paratransit Service. TCRP's Report 121, *Toolkit for Integrating Non-Dedicated Vehicles in Paratransit Service*, is a users' manual for the Non-Dedicated Vehicle Optimization Model (NDV Model) that transit managers can use in deciding the appropriate ratio between dedicated and non-dedicated paratransit service in a systematic and comprehensive manner. The NDV Model and test data are available online in spreadsheet format. In addition to this toolkit, a case study report and an interim report that includes an analysis of factors that influence the mix of dedicated and non-dedicated paratransit service are available for download.

Improving Demand-Response Transportation. Demand-response transportation (DRT) systems are under increasing pressure to improve performance because of increased demand for service and financial constraints. Improving DRT performance requires understanding the characteristics of DRT services and the factors that affect performance. To identify opportunities for improvement, DRT systems need better data and methods to measure and assess performance consistently and systematically. TCRP Report 124, *Guidebook for Measuring, Assessing, and Improving Performance of Demand-Response Transportation*, is designed to help DRT systems measure, assess, and improve their performance. It identifies the important controllable factors that affect DRT performance and includes methods that allow assessments of performance over time and across DRT systems. The methods address the diversity of DRT services, service areas, and passengers. The report focuses on DRT in urban areas.

Transit Employee Compensation in Rural and Small Urban Areas. Transit systems in rural and small urban areas (i.e., populations under 200,000) provide services under a great variety of conditions and with very few resources. Because of constraints in resources and the varying needs of communities, employees of rural and small urban transit systems perform duties that may vary widely from provider to provider, place to place, and even day to day. This variety of situations results in varied compensation levels and practices. TCRP Report 127, *Employee Compensation Guidelines for Transit Providers in Rural and Small Urban Areas*, explores salary and benefit characteristics of transit systems in rural and small urban areas. An interactive computer tool is available online and is designed to allow transit managers to quickly and easily obtain compensation and benefit data from comparable transit systems.

Enhancing Paratransit. TCRP Synthesis 71, *Paratransit Manager's Skills, Qualifications, and Needs*, examines current requirements for paratransit managers and actual experiences of paratransit managers. Information in the synthesis is based on survey data from transit agencies throughout the United States. Transit managers, policy makers, educators, trainers, human resource directors, and stakeholders will find the report valuable for enhancing the paratransit management profession and paratransit service delivery.

Policies and Practices for Meeting ADA Paratransit Demand. TCRP Synthesis 74, *Policies and Practices for Effectively and Efficiently Meeting ADA Paratransit Demand*, is a state-of-the-art summary of policies and practices that transit agencies use to provide effective and efficient service to persons with disabilities. It highlights practices that transit agencies may apply to their own paratransit services, often without expending significant funds, personnel, or other resources. It also examines practices and technologies that are under development or have not undergone extensive testing.

Objective 3.4 Investigate the Use of High-Efficiency Technologies and Alternative Energy Sources

Ultra-Clean Fischer-Tropsch Diesel Fuel. Integrated Concepts and Research Corporation is conducting three demonstrations of ultra-clean Fischer-Tropsch diesel fuel:

- A three-year, 24,000-gallon demonstration at Tulsa Transit. In 2005, Tulsa Transit selected a new bus to run on the ultra-clean Fischer-Tropsch fuel. From August 2005 through July 2008, the bus used approximately 24,000 gallons of fuel over 121,000 miles. Operations and maintenance reported no problems attributable to the fuel during the entire three-year demonstration.
- A three-year, 2,000-gallon demonstration at Edwards Air Force Base in California. Edwards Air Force Base has been running a 2004 model-year base transit bus with a traditional-technology Caterpillar diesel engine since September 2006, with an expectation to continue running through 2009.
- A one-year, 2,000-gallon demonstration at the Selfridge Air National Guard Base in Michigan. Selfridge Air National Guard Base is running a 2005 model-year base transit bus with a new-technology Caterpillar C-7 diesel engine. The demonstration began in October 2008, and is expected to continue through 2009.

Hybrid Bus Emissions and Certification Program. West Virginia University is developing a heavy duty hybrid vehicle emissions test protocol to complement the U.S. EPA's SmartWay fuel economy guidelines. The test protocol will conform to 40 Code of Federal Regulations (CFR) Part 86, On Highway Heavy-Duty Engines; EPA420-P-07-003, *SmartWay Fuel Efficiency Test Protocol for Medium and Heavy Duty Vehicles*; Society of Automotive Engineers (SAE) J2711, "Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy Duty Vehicles;" and California Air Resources Board interim certification procedures.

On-Grid Hybrid Electric Bus. In 2008, the University of Kansas completed final demonstration testing of the first-generation plug-in hybrid-electric vehicle (PHEV) paratransit bus in Kansas City. The bus was initially put into service in 2007 and tested for a spectrum of operating characteristics as well as emissions and fuel economy through the winter of 2007/2008. The draft final emissions report, "Plug-In Hybrid Emissions Characterization and Demonstrations Study," was submitted to FTA in June 2008, and the follow-on report, "PHEV Sprinter Analysis," in July.



During the winter of 2007/2008, this plug-in hybrid electric (PHEV) was tested for emissions and fuel economy.

Advanced Technologies for Transportation. In 2008, the University of Tennessee at Chattanooga (UTC) completed development, testing, and demonstration of a new data acquisition system (DAS) for electric and hybrid-electric buses. The DAS allows public transit agencies to observe, in real time, the impact that an operator or service requirement has on an entire electric or hybrid-electric propulsion system. DAS monitors driving techniques, energy consumption versus road and load conditions, energy requirements of designated routes, and battery recharge. DAS prototypes were installed at public transportation systems in Santa Barbara, CA; Sevierville, TN; and Emory University in Atlanta, GA. The prototypes operated successfully at all three sites, demonstrating that it is commercially viable for installation in electric and hybrid-electric buses.



The new DAS developed at UTC provides real-time monitoring of electric and hybrid-electric buses to help assure compliance with recommended practices.



In conjunction with the Chattanooga Regional Area Transit Authority (CARTA), UTC developed a plan and began installation of a dynamic message sign (DMS) system. The system provides real-time information for transit customers.

Biodiesel Fuel Management Best Practices for Transit

Many transit agencies in the United States have tested or are using biodiesel in blends with petroleum diesel fuel. In addition to environmental, public policy, and energy security benefits, transit agencies receive significant tax incentives for using biodiesel fuels.

Biodiesel Fuel Management Best Practices for Transit describes best practices for the handling and use of biodiesel fuels. Although the properties of biodiesel and petroleum diesel are similar, good fuel handling practices for biodiesel blends requires awareness of differences. This best practices manual addresses biodiesel properties and specifications (including testing protocols), cold weather operations with biodiesel, and good biodiesel fuel management practices, including managing fuel quality and blending.

Hybrid Electric Technologies for Buses. The University of Texas at Austin, Center for Electromechanics (UT-CEM), completed an assessment of advance hybrid electric technologies for heavy trucks and buses. The assessment evaluated both conventional and hydrogen-powered hybrids using advanced technologies. UT-CEM also demonstrated and evaluated a hydrogen fuel cell shuttle bus and a plug-in fuel cell hybrid electric bus (Ebus) from the Gas Technology Institute.



UT-CEM evaluated the performance of a plug-in fuel cell hybrid electric bus and developed a computer simulation model for the bus to provide a benchmark for modeling heavy hybrid vehicles.

Delaware Fuel Cell Bus Program.

The University of Delaware (UD) is designing, building, and demonstrating a fleet of fuel cell buses and creating a network of refueling stations in Delaware. In FY 2008, UD operated its first 22-foot bus on a daily route on the UD campus. As a result of data collection and analysis, modifications and upgrades to the bus included integrating the cell voltage monitoring system, designing and integrating an improved hydrogen heat exchanger, improving the programmable logic controller (PLC) software, implementing communication via Modbus with the bus's traction inverter, and improving the fuel cell control

box. The university also designed a second 22-foot bus with a dual stack and advanced light-weight LiTitanate batteries. EBus of California is fabricating the bus, which is expected for delivery in 2009. Finally, the University of Delaware has begun design of a 30-foot bus for delivery in 2010.

Hydrogen Fuel Cell Bus Demonstration.

This year, the University of Alabama at Birmingham developed a scope of work for designing and demonstrating a 30-foot, low-floor, hydrogen-fuel-cell hybrid-electric direct-drive Ecobus. The kickoff meeting for the demonstration was in September 2008. When complete, the Ecobus will be demonstrated in service by the Birmingham-Jefferson County Transit Authority.



Fueling the University of Delaware 22-seat, 22-foot experimental fuel-cell bus. Incorporated into the University of Delaware shuttle bus system, this bus transports students from dorms to campus.



The Birmingham-Jefferson County Transit Authority will demonstrate the Ecobus, a 30-foot, low-floor, hydrogen-fuel-cell hybrid-electric direct-drive bus.

Fueling Stations for Hydrogen-Fueled Shuttle Buses. During FY 2008, the construction of a hydrogen fueling station was completed at Air Products' Trexlertown, PA, campus. Hydrogen-fueled shuttle buses are now deployed to both the Air Products campus in Trexlertown and the Lehigh Valley Hospital Cedar Crest campus in Allentown, PA, and data collection is underway. The buses will operate in these locations throughout FY 2009, and data, such as mileage, fuel consumption, and run time, will be collected from both the buses and the fueling station.



UT-CEM evaluated the performance of a plug-in fuel cell hybrid electric bus and developed a computer simulation model for the bus to provide a benchmark for modeling heavy hybrid vehicles.

Hydrogen Fuel Cell Transit Bus Evaluations

Since the early 1990s, the Department of Energy (DOE) National Renewable Energy Laboratory (NREL) has been evaluating alternative fuel and advanced propulsion transit buses in cooperation with FTA. Now, FTA and DOE/NREL are collaborating to evaluate all of the hydrogen fuel cell buses in service as part of FTA's National Fuel Cell Bus Program (NFCBP). *Hydrogen Fuel Cell Bus Evaluations: Joint Evaluation Plan for the U.S. Department of Energy and the Federal Transit Administration* describes and discusses these standardized evaluations.

FTA and DOE have acknowledged that lack of data and analysis results from real-world, in-service buses is a challenge for moving fuel cell propulsion technologies forward. The objectives of the joint evaluations are to provide comprehensive, unbiased assessments of fuel cell and hydrogen bus development and performance compared to conventional diesel and compressed natural gas (CNG) buses.

The evaluations will be useful to transit agencies considering future procurements, manufacturers needing to understand the status of the technology for transit applications, and government agencies making policy decisions and determining future research needs.

Fuel Cell Bus Validation and International Coordination. NREL began collecting and analyzing data on the first fuel cell bus demonstration project funded under the National Fuel Cell Bus Program. AC Transit increased the operation time of its three current-generation fuel cell buses and upgraded them to the newest version of fuel cell power systems to identify areas where further development of the technology can be accelerated. Data from the first 11 months of operation show improved performance and reliability.

National Fuel Cell Bus Program

To facilitate the development of commercially viable fuel cell bus technologies and related infrastructure, the Safe, Accountable, Flexible, and Efficient Transportation Equity Act—A Legacy for Users (SAFETEA-LU) authorized \$49 million in grants over a four-year period for the National Fuel Cell Bus Program (NFCBP). Funding under the NFCBP requires a 50-percent match by each grant recipient.

In November 2006, FTA announced the 14 projects selected for the NFCBP. Funded through three non-profit consortia, these projects include eight testing and demonstration projects with 14 fuel cell buses, two component development and testing projects, and four support projects. Highlights and accomplishments through FY 2008 for eight of the 14 projects in the NFCBP include:

The Center for Transportation and the Environment (CTE) in Atlanta, GA

■ **Dual Variable Output Fuel Cell Hybrid Bus Validation Testing and Demonstration.**

This project consists of a clean-sheet design of a 35-foot heavy-duty bus from Proterra in a battery-dominant (plug-in) hybrid fuel cell propulsion configuration with fuel cell system from Hydrogenics. In FY 2008, the first bus was assembled.

■ **Survey of Hydrogen Bus Demonstrations.**

This project is a survey of fuel cell bus demonstrations around the world from 2002 to present. The final report is scheduled for release in April 2009.

The Northeast Advanced Vehicle Consortium (NAVC) in Boston, MA

■ **Lightweight Battery Dominant Hybrid Fuel Cell Bus Project.**

This project explores alternatives in control and integration of advanced technology components into a commercially viable fuel cell bus demonstration vehicle. Plans for the demonstrator bus include a Hydrogenics fuel cell system and lithium ion batteries from A123Systems.

■ **Demonstration of Fuel Cell Buses in Connecticut (Nutmeg Program).**

The Nutmeg Program will develop fuel cell technology, manufacture and operate four fuel cell buses, and gather critical data from the buses to improve durability and reliability and to reduce capital cost of the buses. The four new hybrid fuel cell buses from Van Hool, with fuel cell systems from UTC Power (a United Technologies Company), are on order. The first bus is scheduled for service in 2010.

■ **FTA NFCBP Support.**

NAVC supports FTA on the National Fuel Cell Bus Working Group and the International Fuel Cell Bus Working Group, which met in Reykjavik, Iceland, in May 2008. In addition, NAVC facilitates an annual international fuel cell bus workshop for FTA.

National Fuel Cell Bus Program cont'd

CALSTART in Pasadena, CA

■ Accelerated Testing of Fuel Cell Buses at AC Transit.

This project operates three fuel cell buses from Van Hool and UTC Power at Alameda-Contra Costa Transit District (AC Transit) in Oakland, CA. Its objectives include accelerated testing and operation of these buses to identify weaknesses in the propulsion system and to support technology and component development and upgrades



Accelerated testing of AC Transit fuel cell buses supports development and upgrading of components to increase reliability and durability.

for increased reliability and durability. Accelerated testing started November 2007. The first public evaluation report by NREL is planned for release in FY 2009.

■ Integrated Auxiliary Module for Fuel Cell Bus.

This component project consisted of fabrication and demonstration of a low-cost, compact, water-cooled integrated auxiliary module (IAM). The IAM contains a direct-current-to-direct-current (DC-DC) converter and two small electric motors for auxiliary loads. The converter provides low-voltage power to auxiliary systems. The electric motors drive hydraulic and air systems onboard a vehicle. The converter and drive motors are integrated into a single modular enclosure and controlled through an automotive controller area network (CAN) bus interface (SAE J1939). This integration will increase efficiency and reduce cost over current auxiliary systems.

■ Bi-Directional Converter for Fuel Cell Bus.

This component project scaled the design of an existing automotive fuel cell DC-DC high-power converter to meet a broader range of heavy-duty hybrid fuel cell transit bus requirements. The resulting bi-directional DC-DC converter (BDC) is programmable and is compatible with several energy storage devices (batteries and ultracapacitors) and fuel cell power system products. It will replace the custom designs currently offered by various drive train suppliers for hybrid fuel cell vehicle systems.

Use of Biodiesel in a Transit Fleet. TCRP Synthesis 72, *Use of Biodiesel in a Transit Fleet*, explores the potential benefits of biodiesel to help transit agencies make informed decisions regarding its use. Topics covered include engine manufacturer requirements and warranty considerations, maintenance implications, emissions testing results, cold weather operations, fuel specifications and procurement considerations, fuel storage, and delivery.

Objective 3.5 Perform Research to Reduce Transit Environmental Impacts

Environmental Project Risk and Decision Analysis System

Experience shows that incomplete or missing information from environmental areas can cause significant schedule slippages and cost overruns in the planning, design, and construction of a transit project. To address this problem, FTA commissioned Oklahoma State University to develop a risk assessment tool for early application to the transit project planning process. The tool assesses seven areas of environmental concern:

- Wetlands
- Environmental justice
- Endangered species
- Historic resources
- Property acquisition
- Noise, vibration, and electromagnetic interference
- Property acquisition
- Parklands.

The tool uses data generally available or easily obtained early in the planning process, and should help planners identify potential areas of concern before project budgets and schedules are finalized. Addressing environmental matters at an early stage of project planning assures better environmental protection while also identifying “show stoppers” that delay projects and increase costs. The risk assessment tool is available online at <http://www.ftarisk.okstate.edu>.

Objective 3.6 Perform Research to Improve Safety, Security, and Emergency Preparedness

Wireless High Speed Video for Washington State Ferries. The Ferries Division of the Washington State Department of Transportation developed, tested, and rolled out a prototype system and completed verification and validation of their ferries' wireless high-speed video systems to evaluate the consistent availability of real-time security monitoring in a mobile marine environment. The research was carried out on two ferry routes, Fauntleroy/Vashon Island/Southworth and Port Townsend/Keystone. Monitoring from shore was successful during the ferries' normal daily operations—including inclement weather, high vessel traffic, and varying locations of the ferries—and in emergency situations. The resulting reports, *Washington State Ferries Wireless Connection High Speed Data Project* (FTA/WA-26-7006-2008.02) and *Independent Verification and Validation Report of Washington State Ferries' High Speed Data Project* (FTA/WA-26-7001-2008.02), will help government agencies make decisions about technologies and implementation choices when building new secure high-speed mobile wireless data networks.



The Washington State Ferries Prototype Wireless High Speed Data network project is demonstrating new technologies to provide real-time surveillance and records for law enforcement agencies during emergencies.



Live video from ferry to terminal facilitates real-time security monitoring of ferries during normal daily operations, including inclement weather and high vessel traffic.

Mitigating Bus-Pedestrian Collisions. Bus-pedestrian collisions often cause serious injury or death to pedestrians. These collisions are also bad for drivers, bus passengers, the transit system, and the community as a whole. Even highly experienced bus drivers with a stellar performance records can be involved in collisions with pedestrians and suffer because of the stress of the event. The reputation of a public transit system can be hurt by bus-pedestrian collisions, despite their infrequency and regardless of their circumstances. In addition, bus-pedestrian collisions may lead to expensive litigation and large settlements that can have sizable financial implications for transit systems. TCRP Report 125, *Guidebook for Mitigating Fixed-Route Bus-and-Pedestrian Collisions*, is designed to assist small, medium, and large transit agencies and their communities in developing preventive and remedial strategies for reducing the frequency and severity of bus-pedestrian collisions. The report explores strategies to mitigate collisions, includes case studies on implementing mitigation strategies, and highlights important considerations associated with improving pedestrian safety around transit buses.

Capacity Building, Training, and Technical Assistance

In addition funding research to achieve the goals and objectives of its research program, FTA also funds capacity building, training, and technical assistance activities out of its National Research and Technology Program (NRTP) account. Highlights of 2008 accomplishments capacity building, training, and technical assistance include:

National Transit Institute. In 2008, the National Transit Institute (NTI) provided more than 50 training courses to approximately 5,800 participants representing more than 200 public transit and stakeholder agencies. The courses were offered in classroom and web-based formats.

Project TRANSIT. In 2008, the American Cities Foundation's Transportation Economic Development Initiative (Project TRANSIT) worked with more than 25 community organizations to recruit individuals for job opportunities in transit and provided outreach and training in transportation and transit industries for almost 500 students. Project TRANSIT recruited more than 100 people for job opportunities, 65 of whom completed applications. Sixty-three 11th- and 12th- grade students completed Project TRANSIT's job-readiness training course.

Transit Management Training. The Small Urban & Rural Transit Center (SURTC) developed a 3-day Introduction to Transit Management course for new transit managers, front-line supervisors with management responsibilities, and others who have been in transit management for less than 5 years. The course consists of eight modules, including human resource management; financial management; operations and service design; procurement; vehicle and facility maintenance; safety, security, and emergency management; and drug and alcohol compliance. The course was successfully piloted in Alaska and scheduled for extensive deployment in 2009.

Small Urban & Rural Transit Center Expansion. In FY 2008, SURTC expanded its geographical region from six states to twelve. In addition to North and South Dakota, Montana, Utah, and Wyoming, now included are Alaska, California, Colorado, Iowa, Nebraska, and Texas. This year, SURTC conducted 24 training sessions ranging from passenger service and safety certification classes to marketing, grant writing, and financial and risk management. Attendees included more than 700 individuals from within the expanded geographical region.

Community Transportation Association of America. In 2008, the Community Transportation Association of American (CTAA) produced multiple tools, informational materials, and training in support of transit:

- Public transit and other shared-ride transportation can be efficient and affordable for both employees and employers. To aid employers in developing, accessing, and supporting transportation programs and services to jobs, especially for individuals with disabilities and with low incomes, the CTAA developed the "Employer Participation in Job-Related Transportation Services Toolkit." The toolkit contains strategies and resources to support organizations' taking advantage of transportation options that address employee commuting

needs and that advance business goals, including lowering business expenses, increasing profits, retaining staff, strengthening public image, and addressing unexpected business developments.

- Guaranteed-ride-home (GHR) programs assure that people who have commuted to work will not be left stranded if they have to leave work because of an unforeseen emergency. CTAA Joblinks produced “A Primer on Guaranteed Ride Home Programs.” The primer discusses the benefits of GRH programs, types of sponsoring and partner organizations and their responsibilities, funding options, and implementation and administration. It will assist organizations that have or may be implementing GRH programs to make those programs more effective.
- In June 2008, CTAA hosted the “Employment Transportation: Communities Collaborating for Economic Success” conference on creative solutions for improving employment transportation options. The conference featured speakers from business, workforce development, transit, and product design. The proceedings from the conference, including all written materials and a full written transcript, are available at <http://video.ctaa.org>, and are accessible to people with hearing and visual impairments.
- CTAA Joblinks developed “Transportation Voucher Programs: Enhancing People’s Connection to Employment and Other Quality of Life Destinations.” This primer on transportation voucher programs was launched as a webinar and attended by more than 400 people. It is available at <http://sites.google.com/site/voucherprogram>.
- In conjunction with Easter Seals, Inc., CTAA developed a training curriculum, “Transportation Solutions: Linking People with Their Community,” to guide workforce development, human services, and other agency and community-based professionals in assisting customers in using community transportation options to access quality-of-life destinations.

Partnering in Transit. To facilitate understanding how public-private partnership can work in the U.S. transit industry, the National Council of Public Private Partnerships developed and presented four interactive seminars this year. Approximately 600 individuals from public transportation agencies, state and local governments, and private equity firms participated in these seminars, which were led by prominent industry experts.

Planning Partnerships and Employment Transportation Benefits. Two major studies were completed and published in FY 2008. *Partnerships for the Job Access and Reverse Commute Program: A Multi-Site Study of the Institutional and Coordination Processes behind Employment Transportation for Low-Income Workers* reports the results of the partnership and coordination activities that have enabled employment transportation services to be implemented. *Economic Benefit of Employment Transportation* reports the result of studies of the travel behavior and labor market outcomes experienced by employment service users and forecasts how low-income individuals are expected to benefit over their working lives from improvements in their ability to access of jobs, including higher-paying jobs and training.

Easter Seals Project ACTION. Easter Seals Project ACTION assists in implementing the accessible transportation provisions of the ADA through training, technical assistance, applied research projects, and outreach. This year, through training programs, Project ACTION directly reached 2,500 customers. Another 2,400 customers received informational materials, and 12,250 people received newsletters. In addition, Project ACTION staff made more than 25 presentations at major conferences and advisory committees. A Project ACTION team also

began a strategic mobility management project to develop a person-first approach to integrated transportation services at the community level for people with disabilities, older adults, and persons of limited income.

National Center on Senior Transportation. Established in 2006 as a collaboration between Easter Seals and the National Association of Area Agencies on Aging, the National Center on Senior Transportation (NCST) provides training, technical assistance, and outreach to enhance transportation options for older adults. This year, the NCST provided training in transportation services, innovative transportation options, and mobility management for more than 1,300 individuals representing transit agencies, the aging network, and other stakeholders. NCST also developed and distributed “Transportation by the Numbers: Getting the Most out of Human Service Transportation,”⁹ a financial planning tool for human service providers, supported community coalition building in five localities, and assisted six states in implementing older driver safety planning.

Transit Bus Stops: Ownership, Liability, and Access. TCRP Legal Research Digest 24 explores the different levels of ownership, liability, and maintenance associated with bus stops and bus shelters. It identifies the categories of legal issues associated with ownership and liability, and examines the problems and practices of agencies that have dealt with such problems, including protective provisions in franchise agreements and service provider contracts. It will help transit providers and government officials in understanding the problems associated with bus stops and shelters.

Privacy Issues With the Use of Smart Cards. TCRP Legal Research Digest 25 examines privacy issues associated with the acquisition and storage of financial data and trip information from the use of transit smart cards. It explores who can access the data, what data may be accessed and under what conditions, and how the information can be used.

Resources for Legal Issues Associated with Bus Maintenance. TCRP Legal Research Digest 26 is a useful resource to inform attorneys, administrators, managers, mechanics, operators, supervisors, and other interested persons of current federal and state statutes, regulations, and guidance related to bus maintenance.

Civil Rights Implications of the Allocation of Funds Between Bus and Rail. TCRP Legal Research Digest 27 examines complaints filed with the FTA under Title VI of the Civil Rights Act of 1964, and explores the number of Title VI challenges, the nature of transit agencies’ responses to these challenges, and the U.S. Supreme Court decisions associated with Section 602 disparate impact violations, intentional discrimination claims, and immunity.

⁹ Available at http://projectaction.easterseals.com/site/PageServer?pagename=ESPA_Transportation_by_the_Numbers.

Synthesis of Information Related to Transit Problems. TCRP Research Results Digest 86 presents the progress and status of TCRP Project J-7, "Synthesis of Information Related to Transit Problems," for which the Transportation Research Board is the agency conducting the research. The objective of this project is to select topics and prepare reports on current knowledge and practices within the transit industry. Each report is a compendium of the best knowledge available on the selected topic.

Emergency Preparedness, Response, and Recovery in the Transit Industry. TCRP Research Results Digest 87 is an overview of emergency preparedness programs in public transportation systems in Hong Kong Special Administration Region (SAR), Beijing, and Tangshan in the People's Republic of China; Seoul in the Republic of Korea; and Kobe/Hyogo Prefecture and Tokyo in Japan. It is based on reports by individual team members, including managers from state, local, and regional transportation agencies, and senior executives from FTA, TCRP, and APTA.

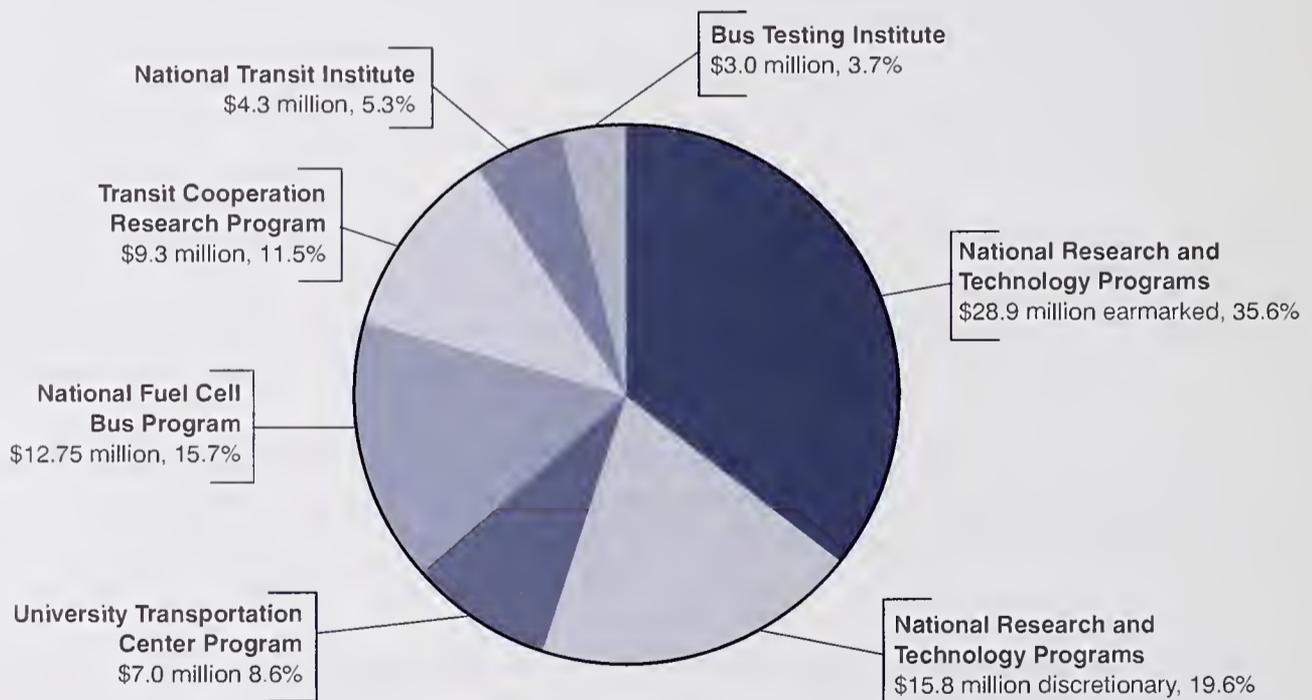
Innovative Practices in Transit Workforce Development. TCRP Research Results Digest 88 examines innovative practices in workforce development in Montreal and Toronto, Canada; Paris and Jouy le Moutier, France; and Brussels, Belgium. It is based on reports by individual team members, including representatives of local, regional, and state transportation agencies across the United States, as well as a senior executive of the FTA.

FY 2008 Funding Charts

FY 2008 Appropriations

In FY 2008, Congress appropriated approximately \$65.4 million for FTA research. Of this amount, Congress provided \$9.3 million for the Transit Cooperative Research Program (TCRP), \$4.3 million for the National Transit Institute (NTI), and \$7.0 million for the University Transportation Centers Program (UTCP) administered by DOT's Research and Innovative Technology Administration (RITA). The balance (\$44.8 million) was provided for the National Research and Technology Program (NRTTP). Of this \$44.8 million, Congress earmarked \$28.9 million for specific projects or programs.

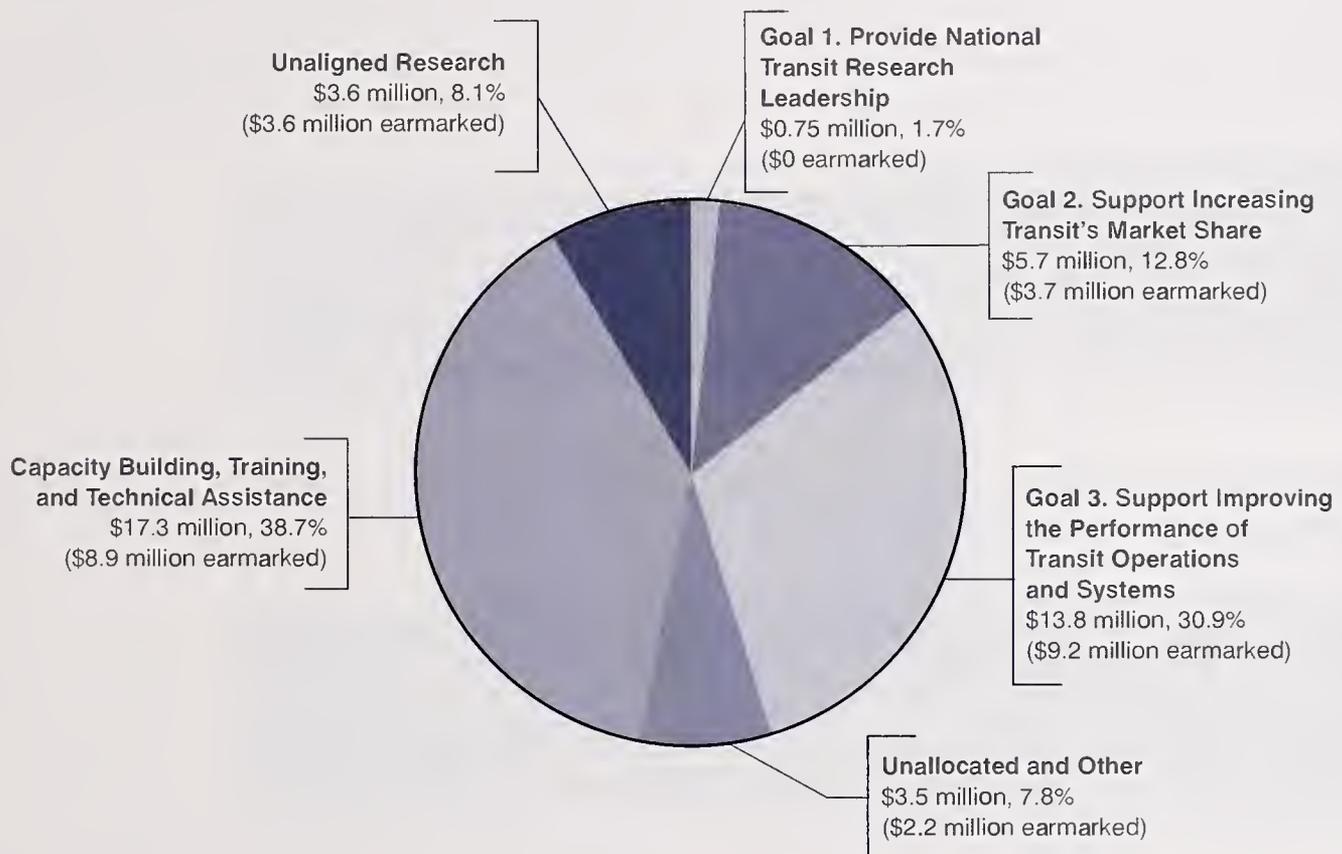
The Research Office also administers funding for the National Fuel Cell Bus Program (\$12.75 million) and the Bus Testing Institute (\$3.0 million), which are funded out of FTA's capital accounts.



FY 2008 Funding

FY 2008 Funding by Strategic Research Goals

FTA's FY 2008 National Research and Technology Program (N RTP) totaled approximately \$44.8 million, of which approximately 64 percent was earmarked for specific projects or programs.



FY 2008 N RTP Funding by Goal*

The \$28.9 million N RTP-earmarked research funds were provided to projects supporting two of FTA's strategic research goals as well as capacity building, training, and technical assistance. Almost 70 percent of these earmarked dollars supported either improving the performance of transit operations and systems or capacity building, training, and technical assistance.

FTA used the \$15.9 million N RTP discretionary research funds to support projects in all three strategic research goals as well as capacity building, training, and technical assistance

* Figures may not match for FY 2008 appropriations due to Small Business Innovative Research (SBIR) deductions, the use of carryover funding, and funds carried over to FY 2009.

FTA Research Performance Measures

FTA had four of its research performance measures in FY 2008. These four measures were defined as part of the Office of Management and Budget (OMB) Program Assessment Rating Tool (PART) process. The goals are designed to be realistic and measurable as well as to allow for steady progress.

Transit Ridership. The 150 largest transit operations in the United States accommodate about 96 percent of transit ridership nationwide. FTA's performance measure captures the average percent increase (decrease) in transit ridership among these agencies adjusted for changes in employment levels in the cities in which the agencies operate. FTA determines changes in employment from studies that document the effect of employment changes on transit ridership.

Transit ridership, adjusted for changes in employment levels, is increasing.

| Year | 2004 | 2005 | 2006 | 2007 | 2008 |
|-------------------------|------|------|------|------|------|
| Percent annual increase | | | | | |
| Target | 2.0 | 1.0 | 1.0 | 1.5 | 1.5 |
| Actual | 0.7 | 1.9 | 2.1 | 2.0 | 4.3 |

Transit Safety. FY 2004 through FY 2008 figures show a general decline in the number of fatalities per 100 million passenger miles traveled.

Transit fatalities per 100 million passenger-miles traveled are declining.

| Year | 2004 | 2005 | 2006 | 2007 | 2008 |
|-------------------------|-------|-------|-------|-------|-------|
| Percent annual increase | | | | | |
| Target | 0.487 | 0.482 | 0.477 | 0.473 | 0.467 |
| Actual | 0.468 | 0.428 | 0.389 | 0.437 | 0.289 |

Research Delivery. FTA tracks major deliverables on an annual basis. FTA is on track to deliver 30 major research products, innovations, and techniques between 2006 and 2010.

FTA annual deliverables are on track.

| Year | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|------------------------|------|------|------|------|------|------|------|
| Number of deliverables | | | | | | | |
| Target | NA | NA | 6 | 6 | 6 | 6 | 6 |
| Actual | 6 | 6 | 6 | 7 | 7 | | |

NA: Data not available.

Research Management Efficiency. FTA examines how well it manages its research projects by measuring on-time and on-budget deliveries.

FTA-managed projects are on track for timely deliveries within budget

| Year | 2004 | 2005 | 2006 | 2007 | 2008 |
|-----------------------|------|------|------|------|------|
| On time and on budget | | | | | |
| Target | NA | NA | 90% | 90% | 90% |
| Actual | 87% | 92% | 91% | 89% | 91% |

NA: Data not available.

Appendix A: Acronyms and Abbreviations

The following acronyms and abbreviations are used in this report.

| | | | |
|------------|--|------------|---|
| AASHTO | American Association of State Highway and Transportation Officials | NAAVC | Northeast Advanced Vehicle Consortium |
| AC Transit | Alameda-Contra Costa Transit District | NCST | National Center on Senior Transportation |
| ADA | Americans with Disabilities Act | NDV | non-dedicated vehicle |
| APC | automated passenger count | NFCBP | National Fuel Cell Bus Program |
| APTA | American Public Transportation Association | NREL | National Renewable Energy Laboratory |
| AVL | automatic vehicle location | NRTP | National Research and Technology Program |
| BDC | bi-directional DC-DC converter | NTCIP | National Transportation Communications for ITS Protocol |
| BRT | Bus Rapid Transit | NTI | National Transit Institute |
| CAD | computer-aided dispatch | OMB | Office of Management and Budget |
| CALSTART | CALSTART Advanced Transportation Technologies | OSU | The Ohio State University |
| CAN | controller area network | PART | Program Assessment Rating Tool |
| CARTA | Chattanooga Area Regional Transit Authority | PCTS | Polk County Transit Services |
| CCTA | Cape Cod Regional Transit Authority | PDA | personal digital assistant |
| CCTV | closed-circuit television | PHEV | plug-in hybrid-electric vehicle |
| CFR | Code of Federal Regulations | PLC | programmable logic controller |
| CNG | compressed natural gas | RFID | radio-frequency identification |
| COTA | Central Ohio Transit Authority | RITA | Research and Innovative Technology Administration |
| CTAA | Community Transportation Association of America | RITS | rural intelligent transportation system |
| CTE | Center for Transportation and the Environment | RP | recommended practice |
| DAS | data acquisition system | RTA | Regional Transit Authority (Chicago) |
| DC | direct current | SAE | Society of Automotive Engineers |
| DC-DC | direct current to direct current | SAFETEA-LU | Safe, Accountable, Flexible, and Efficient Transportation Equity Act – A Legacy for Users |
| DHS | U.S. Department of Homeland Security | SAR | Special Administrative Region |
| DMS | dynamic message sign | SBIR | Small Business Innovative Research |
| DOE | U.S. Department of Energy | SEM | security emergency management |
| DOT | U.S. Department of Transportation | SEPTA | Southeastern Pennsylvania Transit Authority |
| DRT | demand-response transportation | SIS | security infrastructure |
| EDSP | Electric Drive Strategic Plan | SURTC | Small Urban & Rural Transportation Center |
| EPA | U.S. Environmental Protection Agency | TCRP | Transit Cooperative Research Program |
| FTA | Federal Transit Administration | TMCC | Travel Management Coordination Center |
| FY | fiscal year | TOD | transit-oriented development |
| GRH | guaranteed ride home | TRAC | Transit Research Analysis Committee |
| IAM | integrated auxiliary module | TRB | Transportation Research Board |
| ITS | Intelligent Transportation System | TRI | Office of Research, Demonstration, and Innovation |
| ITS JPO | Intelligent Transportation Systems Joint Program Office | UD | University of Delaware |
| LYNX | Central Florida Regional Transportation Authority | UT-CEM | University of Texas, Center for Electromechanics |
| MSAA | Mobility Services for All Americans | UTC | University of Tennessee, Chattanooga |
| NA | Not available | UTCP | University Transportation Centers Program |
| | | UWR | United We Ride |

Appendix B: FTA FY 2008 Reports

Selected FTA FY 2008 Research Reports. FTA staff and contractors produce reports to assist grantees and/or to highlight a particular issue in the transit industry. Most reports are available at <http://www.fta.dot.gov/research.html> unless otherwise noted. Reports are listed alphabetically by title under their respective FTA goals.

Goal 1 Provide National Transit Research Leadership

Electric Drive Strategic Plan. Draft. September 2008.

Multi-Year Research Program Plan (FY 2008 – FY 2012). FTA-OH-26-7245-2007.1. July 2008. Available at http://www.fta.dot.gov/documents/Multi-Year_Research_Program_Plan_2008-12.pdf.

Multi-Year Research Program Plan (FY 2009 – FY 2013). FTA-OH-26-7245-2007.1. September 2008. Available at http://www.fta.dot.gov/documents/FTA_TRI_MYPP_FY09-13.pdf.

Goal 2. Support Increasing Transit's Market Share

2008 Bus Rapid Transit Vehicle Demand & Systems Analysis Update. FTA-CA-26-7074-2008.1. August 2008. Available at http://www.fta.dot.gov/documents/2008_BRT_VDSA_Final.pdf.

Effects of TOD on Housing, Parking, and Travel. TCRP Report 128. October 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_128.pdf.

Evaluation of Transit Applications of Advanced Parking Management Systems. Final Evaluation Report. FTA-TRI-11-2008.1. May 2008. Available at <http://www.fta.dot.gov/documents/Parking-ManagementEvaluationReport.pdf>.

Understanding How to Motivate Communities to Support and Ride Public Transportation. TCRP Report 122. March 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_122.pdf.

Uses of Higher Capacity Buses in Transit Service: A Synthesis of Transit Practice. TCRP Synthesis 75. July 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_syn_75.pdf.

Goal 3. Support Improving the Performance of Transit Operations and Systems

Additional Transit Bus Life Cycle Cost Scenarios Based on Current and Future Fuel Prices. Final Report. FTA-WV-26-7006.2008.1. September 2008. Available at http://www.fta.dot.gov/documents/WVU_FTA_LCC_Second_Report_11-03-2008.pdf.

Advanced Network Planning for Bus Rapid Transit: the "Quickway" Model as a Modal Alternative to "Light Rail Lite". FL-26-7104-4. February 2008. Available at http://www.fta.dot.gov/documents/BRT_Network_Planning_Study_-_Final_Report.pdf.

AVL Systems for Bus Transit: Update. TCRP Synthesis 73. May 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_syn_73.pdf.

Biodiesel Fuel Management Best Practices for Transit. FTA-MO-26-7009.2007.1. November 2007. Available at http://www.fta.dot.gov/documents/Biodiesel_Fuel_Management_Best_Practices_Report.pdf.

Center Truck Performance on Low-Floor Light Rail Vehicles. TCRP Report 114. December 2007. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_114.pdf.

Contractor Performance Incentive Report. Report to Congress. November 2007. Available at http://www.fta.dot.gov/publications/publications_5836.html.

Demonstration of Fischer-Tropsch Diesel Fuel in Cold Climates. AK-26-7005.2007.01. November 2007. Available at http://www.fta.dot.gov/documents/Fischer_Tropsch_Synthetic_Diesel_Demonstration_Project.pdf.

Economic Benefit of Employment Transportation. Final Report to the Federal Transit Administration. P. Thakuria, P.S. Sriraj, S. Soot, and J Persky. U.S. DOT and Community Transportation Association of America. 2008.

Emerging Wireless Technologies for Coordinating Transit and Paratransit Services – A Final Report on the Cape Cod WiFi Project. Written by Lawrence J. Harman and Uma Shama. FTA-MA-26-7098-2007-1. October 2007.

Employee Compensation Guidelines for Transit Providers in Rural and Small Urban Areas. TCRP Report 127. August 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_127.pdf.

An Evaluation of the Market for Small-to-Medium-Sized Cutaway Buses. Final Report. MI-26-7280.07.1. December 2007. Available at <http://www.fta.dot.gov/documents/AnEvaluationofMarketforSmalltoMediumSizedCutawayBuses.pdf>.

FTA Mission to India – Delhi, Ahmedabad, Mumbai – September 20-30, 2007. FTA-FL-26-7104.2007.5. March 2008. Available at http://www.fta.dot.gov/documents/India_Trip_Report_Final_March_2008_2.pdf.

Guidebook for Measuring, Assessing, and Improving Performance of Demand-Response Transportation. TCRP Report 124. April 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_124.pdf.

Guidebook for Mitigating Fixed-Route Bus-and-Pedestrian Collisions. TCRP Report 125, March 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_125.pdf.

Hydrogen and Fuel Cell Transit Bus Evaluations: Joint Evaluation for the U.S. Department of Energy and the Federal Transit Administration. NREL/TP-560-42781-1. May 2008. Available at <http://www.fta.dot.gov/documents/HydrogenandFuelCellTransitBusEvaluations42781-1.pdf>.

Improving ADA Complementary Paratransit Demand Estimation. TCRP Report 119. December 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_119.pdf.

Improving Public Transportation Technology Implementations and Anticipating Emerging Technologies. TCRP Report 84, Volume 8. February 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_84v8.pdf.

Independent Verification and Validation of Washington State Ferries' Wireless High Speed Data Project. FTA-WA-26-7001-2008.02. June 2008. Available at <http://www.fta.dot.gov/documents/CAI-PSC-IVandV-Final-Report-20080910.pdf>.

ITS/Operations Resource Guide 2008. Available at <http://www.resourceguide.its.dot.gov/ITS%20Resource%20Guide%202008v4.pdf>.

Leveraging ITS Data for Transit Market Research: A Practitioner's Guidebook. TCRP Report 126. July 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_126.pdf.

Low Cost Carbon Fiber Technology Development for Carbon Fiber Composite Application. Phase I. Final Report. FTA-TN-26-7028.2007.1. January 2008. Available at http://www.fta.dot.gov/documents/Low_Cost_Carbon_Fiber_Research.pdf.

Paratransit Manager's Skills, Qualification, and Needs. TCRP Synthesis 71. November 2007. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_syn_71.pdf.

Partnerships for the Job Access and Reverse Commute Program: A Multi-Site Study of the Institutional and Coordination Processes behind Employment Transportation for Low-Income Workers. Final Report to the Federal Transit Administration. P. Thakuriah, S. Soot, and P.S. Sriraj. U.S. DOT and Community Transportation Association of America. 2008.

Policies and Practices for Effectively and Efficiently Meeting ADA Paratransit Demand. TCRP Synthesis 74. July 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_syn_74.pdf.

Profiles of Traveler Information Services Update 2008. FTA-TRI30-2008.1. July 2008. Available at http://www.fta.dot.gov/documents/2008_511_Profiles.pdf.

Report on South American Bus Rapid Transit Field Visits: Tracking the Evolution of the Trans-Milenio Model. Final Report. FTA-FL-26-7104.2007.03. December 2007. Available at http://www.fta.dot.gov/documents/Report_on_South_American_Bus_Rapid_Transit_Field_Visits_December_2007.pdf.

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Washington State Ferries Wireless Connection High Speed Data Project. Final Technical Report. FTA/WA-26-7006-2008.02. May 2008. Available at <http://www.fta.dot.gov/research>.

Capacity Building, Training, and Technical Assistance

Civil Rights Implications of the Allocation of Funds between Bus and Rail. TCRP Legal Research Digest 27. September 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_lrd_27.pdf.

Emergency Preparedness, Response, and Recovery in the Transit Industry. TCRP Research Results Digest 87. May 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rrd_87.pdf.

Innovative Practices in Transit Workforce Development. TCRP Research Results Digest 88. July 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rrd_88.pdf.

Privacy Issues with the Use of Smart Cards. TCRP Legal Research Digest 25. May 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_lrd_25.pdf.

Resources for Legal Issues Associated with Bus Maintenance. TCRP Legal Research Digest 26. July 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_lrd_26.pdf.

Synthesis of Information Related to Transit Problems. TCRP Research Results Digest 86. January 2008. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rrd_86.pdf.

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